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(54) Shading compensation and half-tone image forming apparatus

(57) An image forming apparatus is described including a white reference body and an image sensing means for scanning the reference body or a document to produce digital pixel data. The CPU of the apparatus controls the image sensing means to scan the reference body to produce analogue image data, converted to digital pixel data by an ADC. For each pixel, the CPU determines a shading factor by dividing a predetermined maximum brightness value by the digital pixel data. The CPU also controls the image sensing means to scan a document to produce analogue image data, again converted to digital pixel data by the ADC. For each pixel, the CPU determines shading-compensated pixel data by multiplying the digital pixel data by the corresponding shading factors. Finally, a half tone image of the scanned document is produced from the shading-compensated pixel data.

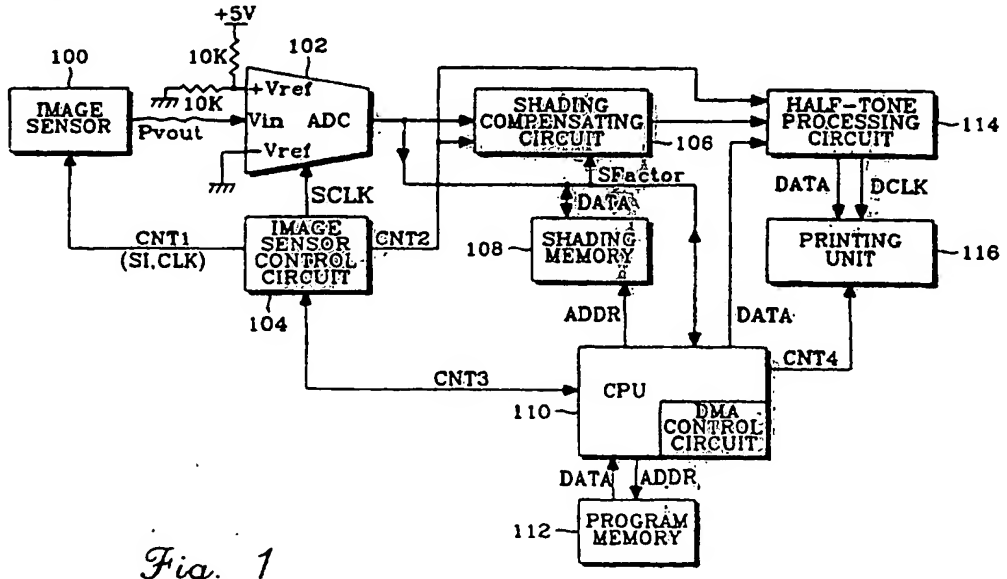

Fig. 1

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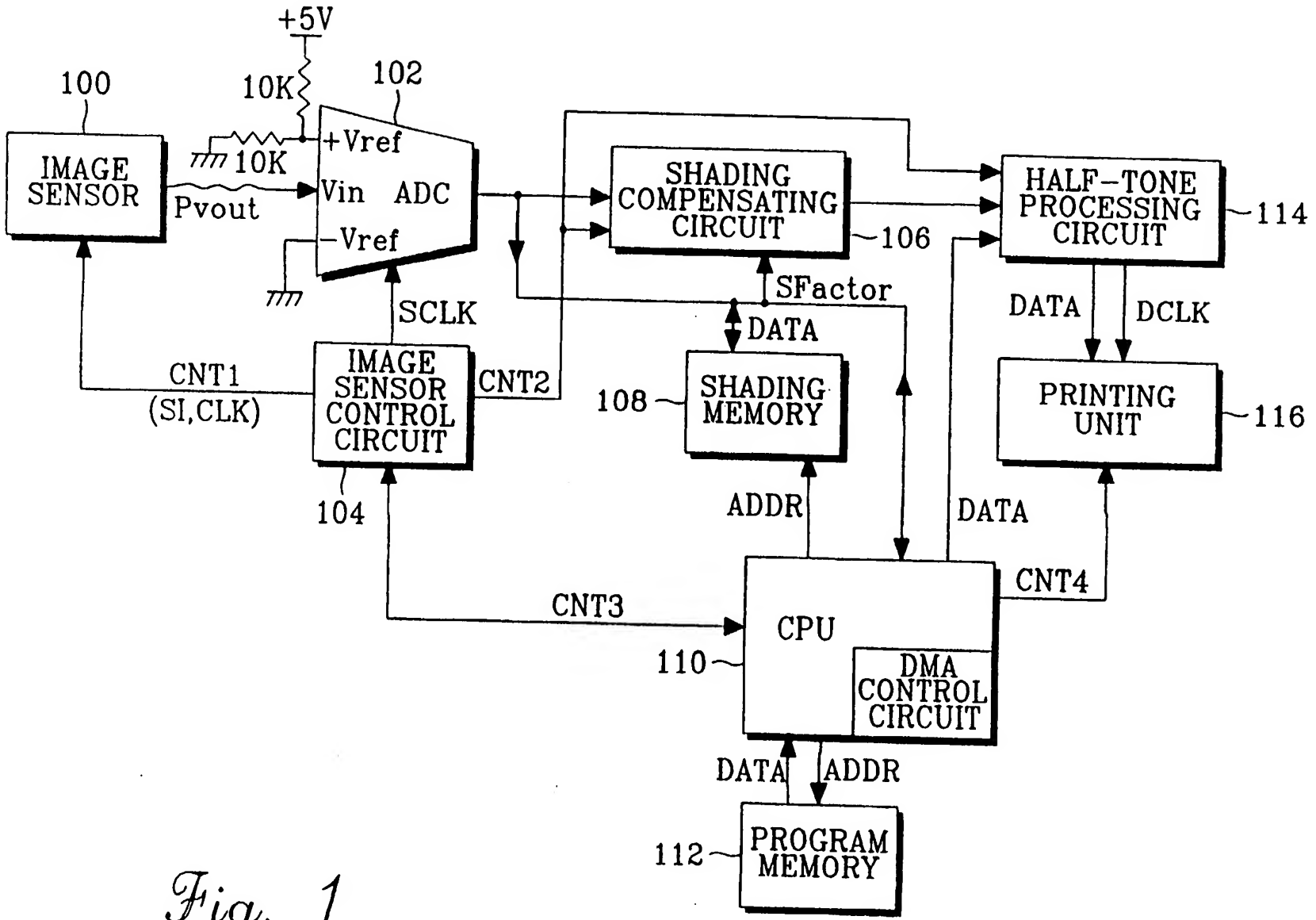
+5V
10K
102
100
+Vref
10K
IMAGE SENSOR
Vin ADC
Pvout
-Vref
SHADING COMPENSATING CIRCUIT
106
HALF-TONE PROCESSING CIRCUIT
114
SFactor
SCLK
DATA
DATA
DCLK
CNT1
(SI,CLK)
IMAGE SENSOR CONTROL CIRCUIT
CNT2
108
SHADING MEMORY
PRINTING UNIT
116
104
ADDR
DATA
CNT4
CNT3
CPU
110
DMA CONTROL CIRCUIT
DATA
ADDR
112
PROGRAM MEMORY

Fig. 1

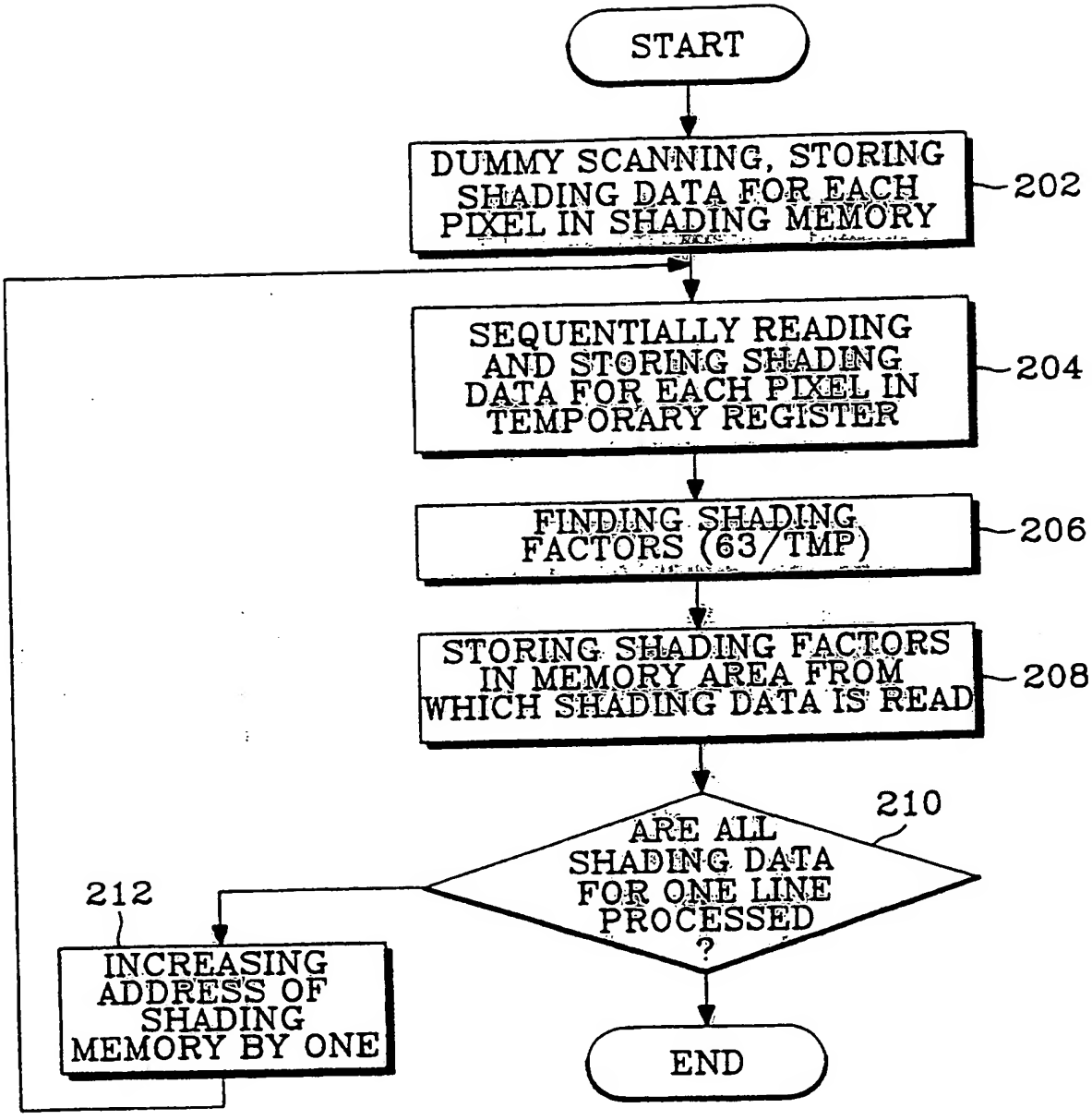
START
DUMMY SCANNING, STORING SHADING DATA FOR EACH PIXEL IN SHADING MEMORY
202
SEQUENTIALLY READING AND STORING SHADING DATA FOR EACH PIXEL IN TEMPORARY REGISTER
204
FINDING SHADING FACTORS (63/TMP)
206
STORING SHADING FACTORS IN MEMORY AREA FROM WHICH SHADING DATA IS READ
208
ARE ALL SHADING DATA FOR ONE LINE PROCESSED ?
210
212
INCREASING ADDRESS OF SHADING MEMORY BY ONE
END

Fig. 2

IMAGE FORMING APPARATUS FOR HALF-TONE RECORDING AND SHADING COMPENSATION AND HALF-TONE IMAGE FORMING METHOD

BACKGROUND OF THE INVENTION

The present invention relates to an image forming apparatus which is of improved construction that simplifies shading compensating operations and half-tone recording. The present invention also relates to a half-tone image forming method.

Image forming apparatus such as digital photocopying machines or facsimile machines are system in which graphic material in the form of an original copy is scanned and converted into an electrical signal to be reproduced on paper. Such an image forming apparatus produces a half-tone image by scanning a document with a light source. The resulting analog image signal, produced during document scanning, is converted into a digital signal by an analog-to-digital converter (ADC).

In the conventional technique, the reference voltage of the ADC is fixed without consideration of the respective output characteristics of the image sensors. Thus, image forming apparatus, employing such a half-tone recording method, and which are mass-produced, may produce printed images with different half-tones, and at worst the gradation of images becomes unclear.

To solve this problem, the system described in Korea Patent Application No. 93-5325 was proposed. Using this system, the maximum amplitude of the image signal, produced by an image sensor during half-tone recording, is determined, and 90 to 95% of this maximum image signal (voltage) serves as the reference voltage (+Vref), thus determining the dynamic range of the analog-to-digital converter.

The above technique requires the ability to control the reference voltage, and requires a digital-to-analog

converter (DAC) to convert digital signals to corresponding analog signals. The presence of the DAC is a complication of the image forming apparatus.

It is an objective of the present invention to provide an image forming apparatus which has a less complicated construction and performs half-tone recording and shading compensation with increased speed.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides an image forming apparatus comprising a reference body; image sensing means for scanning the reference body or a document to produce digital pixel data; control means adapted to control the image sensing means to scan the reference body to produce digital pixel data and, for each pixel, to determine a shading factor from the digital pixel data and a predetermined brightness value; the control means being further adapted to control the image sensing means to scan a document to produce digital pixel data and, for each pixel, to determine shading-compensated pixel data by applying the corresponding shading factor to the digital pixel data; and means for producing a half tone image of the scanned document from the shading-compensated pixel data.

Preferably, the image sensing means comprises an image sensor for producing an analog image signal and an analog-to-digital converter to convert the analog image signal into digital pixel data having a predetermined number of bits (m).

The apparatus may further comprise a shading memory for storing the digital pixel data scanned from the reference body and the corresponding shading factors. The apparatus may further comprise means for printing the said half-tone image.

The present invention also provides a half-tone image

forming method comprising scanning a reference body to produce digital pixel data; for each pixel, determining a shading factor from the digital pixel data and a predetermined brightness value; scanning a document to produce digital pixel data; for each pixel, determining shading-compensated pixel data by applying the corresponding shading factor to the digital pixel data; and producing a half tone image of the scanned document from the shading-compensated pixel data.

Preferably, the digital pixel data are produced by scanning the reference body or the document to produce an analog image signal; and converting the analog image signal into digital image data having a predetermined number of bits (m).

Preferably, the shading factors are determined by dividing the predetermined brightness value by the pixel data.

The reference body may be white and the predetermined brightness value is a maximum brightness value (M). The relationship between m and M is, preferably, $M = 2^m - 1$.

The shading-compensated pixel data may be determined by multiplying the digital pixel data by the corresponding shading factors.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a block diagram of an image forming apparatus in accordance with the present invention; and

FIG. 2 is a flow chart of the control sequence of an image forming apparatus in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIG. 1, an image forming apparatus of the

present invention has an image sensor 100, that scans a document to generate an analog image signal Pvout and an analog-digital converter, (ADC) 102, which converts signal Pvout, from image sensor 100, into digital image data with a dynamic range determined by reference voltages +Vref and -Vref.

The image forming apparatus also has a shading memory 108, which is controlled by a central processing unit 110, for the purposes of storing the image data from ADC 102 during dummy scanning, and the shading factors, SFactor, that are generated for each pixel. A shading compensating circuit 106, multiplies the image data, obtained during a real scanning operation under the control of the CPU 110, by shading factors SFactor, which were stored in shading memory 108, to produce shading-compensated image data.

A half-tone processing circuit 114, generates a half tone image from the real-scanned image data and the output of shading compensating circuit 106 and a printing unit 116 prints the image processed by half-tone processing circuit 114.

Image sensor 100 scans a document in response to a first control signal CNT1 (line synchronizing signal SI, synchronizing clock CLK), that is generated by an image sensor control circuit 104. ADC 102 converts analog image signal Pvout to m-bit digital image data, determined by a sampling clock SCLK produced by image sensor control circuit 104. Shading compensation circuit 106 and half-tone processing circuit 114, perform the shading compensation and the half-tone recording processes, respectively, in response to a second control signal, CNT2, which is output by image sensor control circuit 104.

The CPU 110 controls the dummy scanning and real scanning operations according to a program stored in program memory 112. The CPU 110 includes a direct memory access (DMA) control circuit, which directly accesses the image data

from ADC 102, generated during dummy scanning, and stores it in shading memory 108. The CPU 110 applies to shading compensating circuit 106, the shading factors SFactors corresponding to each pixel that were stored in shading memory 108 during the real scanning operation, and inputs the inverse values to half-tone processing circuit 114, so as to produce a half-tone image. The CPU 110 generates a fourth control signal CNT4 for printing unit 116 using information from half-tone processing circuit 114.

With reference to FIG. 2, the dummy scanning of the inventive image forming apparatus will be fully described. The CPU 110 produces (S202) a third control signal, CNT3, for image sensor control circuit 104 to start dummy scanning, and controls the DMA control circuit, so that output image data from ADC 102 is stored, as shading data, by pixel in the least significant address to the most significant address of shading memory 108. During the dummy scanning mode, image sensor 100 scans a white panel or white roller mounted opposite the image sensor.

Once dummy scanning has been completed, the CPU 110 copies (S204) the shading data, stored in the least significant address of shading memory 108, to a temporary register (TMP) within shading memory 108. The CPU 110 then divides (S206) a preset maximum brightness value by the value of the shading data, previously stored in TMP, and stores (S208) the resultant value as a shading factor in the least significant address of shading memory 108, from where the shading data was originally read.

After that, the CPU 110 increases the address in the shading memory 108 one by one (S212) and repeats Step 204 to S206. The CPU 110 then finds the shading factor for shading data stored and returns to Step 208 to store the shading factor in the corresponding address of shading memory 108. The CPU 110 repeats the above operation until it determines (S210), that the shading factors for the pixels which constitute a complete line of the image have

been determined, i.e. shading data for one line are all processed.

Following the above operation, the shading factors for one line of image data are stored in shading memory 108. The CPU 110 controls image sensor control circuit 104 to perform a real scanning operation, and image data from ADC 102 is input to shading compensating circuit 106. The CPU 110 reads successive shading factors, SFactor, stored in the least significant address to the most significant address of shading memory 108, and applies them to shading compensating circuit 106. Shading compensating circuit 106 multiplies the value of the image data from ADC 102, by the corresponding shading factor in shading memory 108, to produce shading-compensated image data.

Half-tone processing circuit 114, produces a half-tone image using output image data from shading compensating circuit 106, and an inverse value provided by the CPU 110. Printing unit 116, prints the half-tone image on paper.

If ADC 102 converts an analog image signal, Pvout, into digital image data in the form of 6-bit pixels, image sensor control circuit 104 applies a 6-bit sampling clock, SCLK, to ADC 102 under the control of the CPU 110. The CPU 110 sets the maximum brightness value to 63_{10} ($= 2^6-1$), to determine shading factors for each pixel, and sends a series of inverse values such as 2, 6, 10, 14, 16,..., 54, 58, 62 to the half-tone processing circuit 114.

The image forming circuit of the present invention requires only a simple circuit to provide a reference voltage for the ADC. The present invention determines shading factors for each pixel by dividing the preset maximum brightness value by each pixel value, stored in shading memory, and thus reduces the time it takes to perform the shading compensation operation.

CLAIMS:

1. An image forming apparatus comprising:

a reference body;

image sensing means for scanning the reference body or a document to produce digital pixel data;

control means adapted to control the image sensing means to scan the reference body to produce digital pixel data and, for each pixel, to determine a shading factor from the digital pixel data and a predetermined brightness value;

the control means being further adapted to control the image sensing means to scan a document to produce digital pixel data and, for each pixel, to determine shading-compensated pixel data by applying the corresponding shading factor to the digital pixel data; and

means for producing a half tone image of the scanned document from the shading-compensated pixel data.

2. Apparatus according to claim 1 in which the image sensing means comprises an image sensor for producing an analog image signal and an analog-to-digital converter to convert the analog image signal into digital pixel data having a predetermined number of bits (m).

3. Apparatus according to claim 1 or claim 2 further comprising a shading memory for storing the digital pixel data scanned from the reference body and the corresponding shading factors.

4. Apparatus according to any preceding claim in which the control means is adapted to determine the shading factors by dividing a predetermined brightness value by the digital pixel data.

5. Apparatus according to any preceding claim in which the reference body is white and the predetermined brightness value is a maximum brightness value (M).

6. Apparatus according to claim 2 in which the reference body is white and the predetermined brightness value is a maximum brightness value (M) and the relationship between m and M is:

$$M = 2^m - 1.$$

7. Apparatus according to any preceding claim in which the control means is adapted to determine the shading-compensated pixel data by multiplying the digital pixel data by the corresponding shading factors.

8. Apparatus according to any preceding claim, further comprising means for printing the said half-tone image.

9. An image forming apparatus substantially as described with reference to and/or as illustrated in the accompanying drawings.

10. A half-tone image forming method comprising:

scanning a reference body to produce digital pixel data;

for each pixel, determining a shading factor from the digital pixel data and a predetermined brightness value;

scanning a document to produce digital pixel data;

for each pixel, determining shading-compensated pixel data by applying the corresponding shading factor to the digital pixel data; and

producing a half tone image of the scanned document from the shading-compensated pixel data.

11. A method according to claim 10 in which the digital pixel data are produced by:

scanning the reference body or the document to produce an analog image signal; and

converting the analog image signal into digital image data having a predetermined number of bits (m).

12. A method according to claim 10 or claim 11 in which the shading factors are determined by dividing the

predetermined brightness value by the pixel data.

13. A method according to any one of claims 10-12 in which the reference body is white and the predetermined brightness value is a maximum brightness value (M).

14. A method according to claim 11 in which the reference body is white and the predetermined brightness value is a maximum brightness value (M) and the relationship between m and M is:

$$M = 2^m - 1.$$

15. A method according to any one of claims 10-14 in which the shading factors are stored in a memory.

16. A method according to any one of claims 10-15 in which the shading-compensated pixel data is determined by multiplying the digital pixel data by the corresponding shading factors.

17. A half-tone image forming method substantially as described with reference to and/or as illustrated in the accompanying drawings.

The Patent Office

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Application No: GB 9707273.0
Claims searched: 1-17

Examiner: John Coules
Date of search: 22 May 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4F FHHB,FHHX

Int Cl (Ed.6): H04N 1/401,1/403,1/407,1/409,5/217

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2292283 A (SAMSUNG) see pages 7 and 8	1 and 10 at least
X	EP 0200438 A2 (OLIVETTI) see fig 3	1 and 10 at least
X	EP 0024470 A2 (BALL) see fig 3	1 and 10 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.